## REMARKS/ARGUMENTS

Favorable reconsideration of this application as presently amended and in light of the following discussion is respectfully requested.

Claims 1-4, 17-35, 56-58, and 60-65 are pending in the present application. Claims 60 and 61 are amended without adding new matter and Claim 59 is cancelled without prejudice by the present amendment.

In the outstanding Office Action, Claims 59-62 were objected to; Claims 1-4, 17, 18, 20, and 22-27 were rejected under 35 U.S.C. § 103(a) as unpatentable over Molotkov et al. ("Quantum Cryptography Based on Quantum Dots", herein "Molotkov") in view of Sugiyama (U.S. Patent No. 6,177,684, herein "Sugiyama '684"); Claims 19, 21, and 30-34 were rejected under 35 U.S.C. § 103(a) as unpatentable over Molotkov in view of Sugiyama '684 and Crow (U.S. Patent No. 5,423,798); Claims 28 and 29 were rejected under 35 U.S.C. § 103(a) as unpatentable over Molotkov in view of Sugiyama '684 and Cho et al. (U.S. Patent No. 5,314,838, herein "Cho"); Claim 56 was rejected under 35 U.S.C. § 103(a) as unpatentable over Molotkov in view of Sugiyama '684 and Sugiyama (U.S. Patent No. 6,281,519, herein "Sugiyama '519"); Claims 57-63 were rejected under 35 U.S.C. § 103(a) as unpatentable over Molotkov in view of Sugiyama '519; and Claims 64 and 65 were rejected under 35 U.S.C. § 103(a) as unpatentable over Molotkov in view of Fafard (U.S. Patent No. 6,768,754).

Regarding the objection to Claims 59-62, Claim 59 has been cancelled and Claims 60 and 61 have been amended to depend from Claim 57 instead of now cancelled Claim 59. No new matter has been added.

Regarding the rejection of Claims 1-4, 17, 18, 20, and 22-27 under 35 U.S.C. § 103(a) as unpatentable over Molotkov in view of Sugiyama '684, this rejection is respectfully traversed for the following reasons.

Briefly recapitulating, independent Claim 1 is directed to a photon source that allows emission of a predetermined number of photons at predetermined times. The photon source includes a quantum dot and an electrical supply unit. The quantum dot has a first confined energy level capable of being populated with a first carrier, which is an electron, and a second confined energy level capable of being populated by a second carrier, which is a hole. The electrical supply unit electrically supplies carriers to at least one of the energy levels to allow recombination of carriers in the quantum dot to emit at least one photon.

In a non-limiting example, Figure 17 shows the quantum dot layer 109 and the electrical supply unit including a doped barrier layer 113 that supplies holes, and an injection layer 105 that supplies electrons.[1]

Turning to the applied art, Molotkov shows in Figure 1a and discloses at page 688, second paragraph, that the supply unit of a quantum dot is ***optical*** "with circularly polarized light." Further, Molotkov states "[a] single electron is excited to the conduction band by resonant illumination" and then the "selection rules [associated with the use of circularly polarized light] guarantee that precisely one electron (with appropriate spin) is excited to the doubly degenerate (in spin) level." Thus, Molotkov requires a precise optical frequency to excite a single electron with a particular spin to the conduction band by resonant illumination.

Sugiyama '684 shows in Figure 6 quantum dots 26 that are supplied with electrons from electrodes 31 and 32. Because Sugiyama '684 does not teach or suggest any element that determines a spin orientation of the electrons supplied by the electrodes 31 and 32, the

[1] Specification, page 35, last paragraph.

electrons supplied by the electrodes 31 and 32 have multiple spin orientations. However, Molotkov requires only "one electron (with appropriate spin)."

Thus, Applicants respectfully submit that it is not clear how the optical supply of electrons with the appropriate spin in Molotkov is substituted with an electrical supply of electrons as taught in Sugiyama '684 that produces multiple spin orientations without modifying the principle of operation of the device in Molotkov. Also, there is no evidence that a person of ordinary skill in the art would be motivated to perform such changes and redesign.[2]

Further, Molotkov discloses on page 688, second paragraph, that the incident illumination is resonant with a transition energy of the quantum dot, $\omega \approx \omega_1$. In addition, Molotkov discloses in the paragraph bridging pages 688 and 689 that it is important that the laser pulse does not have a short time duration ($>10^{-12}$ s), since "otherwise the inevitable frequency uncertainty would result in electron excitation not only to the size-quantized level but also to the conduction band of the bulk crystal."

However, Sugiyama '684 shows in Figure 7 that the electrical supply unit supplies carriers via GaAs barrier layers. Applicants respectfully submit that carriers supplied in this manner cannot be resonant with the quantum dot energy level as required by Molotkov. Thus, it is respectfully submitted that one of ordinary skill in the art would not have combined the applied references because the references are based on different principles, and the teachings of Molotkov indicate that the teachings of Sugiyama '684 will not achieve a reliable separation of the spontaneous radiation of single photons, as required in Molotkov.

[2] See In re Ratti, 270 F.2d 810, 813, 123 USPQ 349, 352 (reversing an obviousness rejection where the "suggested combination of references would require a substantial reconstruction and redesign of the elements shown in [the primary reference] as well as a change in the basic principle under which the [primary reference] construction was designed to operate.")

Furthermore, Applicants note that Molotkov teaches generating only (i) single photons by using a single quantum dot (see Figure 1) and (ii) pairs of photons by using two quantum dots (see Figure 2). Molotkov states in the paragraph bridging pages 690 and 691 that the device uses "a pair of tunnel-coupled quantum dots to produce a correlated photon pair." On the contrary, Sugiyama '684 shows in Figures 6-9 a plurality of quantum dots that are electrically excited (this is also the case in the device of Fafard) because for laser and LED devices it is generally advantageous to have as many quantum dots as possible.

Thus, Sugiyama '684 and Fafard do not teach or suggest (i) the emission of photons from a predetermined number of quantum dots (one or two in Molotkov), and (ii) the emission of a predetermined number of photons, as required in Claim 1. For these reasons, it is further submitted that one of ordinary skill in the art would have not combined the teachings of Molotkov of exciting a single quantum dot with the teachings of Sugiyama '684 of exciting a plurality of quantum dots.

Moreover, Molotkov does not teach or suggest how to fabricate the quantum dot. Molotkov merely mentions that the quantum dot is formed by molecular beam epitaxy of GaAs/AlGaAs compounds.[3] This method of forming the quantum dot is latticed matched and grows 2D layers. The quantum dot may be formed in these 2D layers by etching mesas which have lateral dimensions of 1 micron or less. Although such structure could be optically excited as Molotkov suggests, Applicants respectfully submit that it is not clear from the record how the quantum dots could be electrically excited as suggested by the outstanding Office Action at page 3, last paragraph.

[3] Molotkov, paragraph briding pages 688 and 689.

Sugiyama '684 does not teach how to electrically excite the specific quantum dots of Molotkov as the device of Sugiyama '684 includes a plurality of quantum dots and the quantum dots are excited via the GaAs barrier layers.

Thus, Applicants respectfully submit that the combination of Molotkov and Sugiyama '684 is improper for the reasons discussed above, and Claim 1 and each of the claims depending therefrom patentably distinguish over Molotkov and Sugiyama '684, either alone or in combination.

Regarding the rejection of Claims 19, 21, and 30-34 under 35 U.S.C. § 103(a) as unpatentable over Molotkov in view of Sugiyama '684 and Crow, Applicants respectfully traverse this rejection for the following reasons.

The outstanding Office Action relies on Crow for teaching a light source coupled to a fiber optic. However, Crow does not overcome the deficiencies of Molotkov and Sugiyama '684 discussed above. In addition, Claims 19, 21, and 30-34 dependent directly or indirectly from independent Claim 1, which is believed to be allowable as noted above.

Accordingly, it is respectfully submitted that dependent Claims 19, 21, and 30-34 are also allowable.

Regarding the rejection of Claims 28 and 29 under 35 U.S.C. § 103(a) as unpatentable over Molotkov in view of Sugiyama '684 and Cho, Applicants respectfully traverse this rejection for the following reasons.

The outstanding Office Action relies on Cho for teaching a Bragg mirror. However, Cho does not overcome the deficiencies of Molotkov and Sugiyama '684 discussed above. In addition, Claims 28 and 29 dependent indirectly from independent Claim 1, which is believed to be allowable as noted above.

Accordingly, it is respectfully submitted that dependent Claims 28 and 29 are also allowable.

Regarding the rejection of Claim 56 under 35 U.S.C. § 103(a) as unpatentable over Molotkov in view of Sugiyama '684 and Sugiyama '519, Applicants respectfully traverse this rejection for the following reasons.

The outstanding Office Action relies on Sugiyama '519 for teaching a quantum dot encapsulated between two layers. However, Sugiyama '519 does not overcome the deficiencies of Molotkov and Sugiyama '684 discussed above. In addition, Claim 56 dependents from independent Claim 1, which is believed to be allowable as noted above.

Accordingly, it is respectfully submitted that dependent Claim 56 is also allowable.

Regarding the rejection of Claims 57-63 under 35 U.S.C. § 103(a) as unpatentable over Molotkov in view of Sugiyama '519, Applicants respectfully traverse this rejection for the following reasons.

Independent Claim 57 is directed to a photon source that includes, inter alia, a quantum dot encapsulated between two layers having different lattice constants than the quantum dot.

The outstanding Office Action recognizes in the paragraph bridging pages 9 and 10 that Molotkov does not teach or suggest encapsulating the quantum dot between two layers with the claimed properties. The outstanding Office Action relies on Sugiyama '519 for teaching the features lacking in Molotkov.

Applicants note that Molotkov teaches a device having a single quantum dot (or two coupled quantum dots in Figure 2) with lattice matched barrier layers. Although Molotkov

does not explicitly state that the device uses lattice matched materials, the only material of the device disclosed in Molotkov is GaAs/AlGaAs, which is lattice matched.[4]

Sugiyama '519 discloses a self-organizing process that produces quantum dots with a large density. Applicants respectfully submit that it is not clear from the record how a self-organizing plurality of quantum dots, with lattice miss-matched barrier layers, as disclosed in Sugiyama '519 could be used in the device of Molotkov that uses one or two quantum dots and lattice matched layers. In addition, Applicants respectfully submit that one of ordinary skill in the art would have not combined the teachings of Molotkov and Sugiyama '519 because it is not clear how to isolate the emission of a single quantum dot (as required in Molotkov) from the high number of quantum dots (disclosed by Sugiyama '519).

Further, Applicants note that the memory device of Sugiyama '519 (see Title) would not be considered by one of ordinary skill in the art analogous to the technology of Molotkov (i.e., photon sources) because the energy levels in the dots and barrier layers (accumulation layers in the terminology of Sugiyama '519) are configured so that there is ***no*** optical recombination in the dots. Figure 3 of Sugiyama '519 shows that the electrons are transferred from the dots after excitation, thereby preventing the recombination of the electrons with the holes, and preventing optical emissions. This is contrary to the principle of operation of Molotkov.

Thus, it is respectfully submitted that independent Claim 57 and each of the claims depending therefrom patentably distinguish over Molotkov and Sugiyama '519, either alone or in combination.

[4] Molotkov, paragraph bridging pages 688 and 689.

Independent Claim 63 is directed to a photon source that has, inter alia, a modulation unit for varying transition energies of a quantum dot. Neither Molotkov nor Sugiyama '519 teaches or suggests the claimed modulation unit.

Thus, it is respectfully submitted that independent Claim 63 patentably distinguishes over Molotkov and Sugiyama '519, either alone or in combination.

Regarding the rejection of Claims 64 and 65 under 35 U.S.C. § 103(a) as unpatentable over Molotkov in view of Fafard, that rejection is respectfully traversed for the following reasons.

Independent Claim 64 is directed to a photon source that has, inter alia, a plurality of quantum dots and a filter that selects photons of a particular energy emitted from just one quantum dot.

As discussed above, Molotkov discloses in the paragraph bridging pages 690 and 691 a device in which two tunnel coupled quantum dots are used to create photon pairs. Molotkov is silent about using a plurality of quantum dots as required by Claim 64. Molotkov also does not use a filter to select a photon from just one quantum dot.

Fafard discloses the use of a filter in an external cavity quantum dot laser to select an emission wavelength. However, Fafard does not teach or suggest using the filter to select a photon from ***just one quantum dot*** as required in Claim 64. Thus, it is not clear how one of ordinary skill in the art would use the filter of Fafard, which is designed for an external laser, to select a photon from just one quantum dot.

Accordingly, it is respectfully submitted that independent Claim 64 patentably distinguishes over Molotkov and Fafard, either alone or in combination.

Independent Claim 65 is directed to a photon source that has, inter alia, a supply unit for supplying carriers to energy levels. The supply unit selectively injects or excites carriers

of a predetermined energy into one of the energy levels of just one quantum dot. The carriers then recombine within the excited dot(s) to emit one (or a predetermined number of) photon(s).

As discussed above, Molotkov discloses a system having two tunnel coupled quantum dots that creates pairs of photons. However, one of the two quantum dots in Molotkov is resonantly excited and carriers created in the first (resonantly excited) quantum dot are transferred to the second quantum dot and these carriers as well as a second pair of carriers created in the first quantum dot recombine to emit a pair of photons. Thus the carriers of the device of Molotkov do not recombine in the same quantum dot where the carriers are (resonantly) created, as required in Claim 65. Thus, a single photon emission cannot be achieved by the device of Molotkov.

The outstanding Office Action recognizes at page 12, last paragraph, that Fafard does not teach or suggest "injecting/exciting only one quantum dot." The outstanding Office Action asserts that it is obvious to filter the ***emitted*** light in Fafard to achieve injection of carriers into a single quantum dot. However, Applicants respectfully submit that filtering light separates different light frequencies but does not control the number of photons emitted by a source light.

Thus, Applicants respectfully submit that neither Molotkov nor Fafard teaches or suggests a supply unit that selectively injects or excites carriers of a predetermined energy into one of the energy levels of just one quantum dot, as required in Claim 65.

Accordingly, it is respectfully submitted that independent Claim 65 patentably distinguishes over Molotkov and Fafard, either alone or in combination.

Consequently, in light of the above discussion and in view of the present amendment, the present application is believed to be in condition for allowance and an early and favorable action to that effect is respectfully requested.

Respectfully submitted,

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